

## FUEL INJECTOR

## Background Information

The present invention is based on a fuel injector of the type set forth in the main claim.

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Known from DE 101 52 415 A1, for instance, is an outwardly opening fuel injector having a conical sealing seat. The fuel injector includes a valve needle, which is guided in a nozzle body, is actuable by an actuator and acted upon by a restoring spring in such a manner that a valve-closure member, which is in operative connection with the valve needle, is retained in sealing contact on a valve-seat surface. Formed on a downstream end of the fuel injector is a projection, which juts out beyond the valve-closure body of the fuel injector.

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A particular disadvantage of the fuel injector known from DE 101 52 415 A1 is that the manufacture of the raised area of the nozzle body compared to the valve-closure body, while protecting the conical sealing seat from damage, is labor-intensive in the production and itself is susceptible to damage because of its exposed position, such damage having an adverse effect on the jet pattern of the fuel injector and also on the desired protective function of the raised region.

## 25 Summary of the Invention

In contrast, the fuel injector according to the present invention, having the characterizing features of the main claim, has the advantage that simple measures with respect to the contour of the nozzle body and the valve-closure body provide reliable protection of the sealing seat against mechanical damage during transportation and installation of

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the fuel injector in that a transition region between the nozzle body and the valve-closure body has a concave design.

Advantageous further developments of the fuel injector specified in the main claim are rendered possible by the measures elucidated in the dependent claims.

In an advantageous manner an angle between the mutually abutting surfaces of the nozzle body and the valve-closure body amounts to less than  $180^\circ$ , so that the sum of the two edge angles of the edges on the nozzle body and the valve-closure body is greater than  $180^\circ$ , i.e., the two edges are obtuse-angled.

Moreover, it is advantageous that the transition region with the edges is positioned in a recessed manner compared to a surface plane of the fuel injector.

#### Brief Description of the Drawing

An exemplary embodiment of the present invention is represented in simplified form in the drawing and elucidated in greater detail in the following description.

The figures show:

Fig. 1 a schematic section through an exemplary embodiment of a fuel injector configured according to the present invention;

Fig. 2 a schematic comparative sectional view of the exemplary embodiment of the fuel injector configured according to the present invention, shown in Figure 1, in region II in Figure 1, and a fuel injector according to the related art; and

Fig. 3 a schematic comparative illustration of a sealing  
seat of a fuel injector according to the related art  
and a fuel injector according to the present  
invention in the open state of the fuel injector.

#### Detailed Description of the Exemplary Embodiment

An exemplary embodiment of a fuel injector 1 according to the  
present invention, shown in Figure 1, is designed in the form  
of a fuel injector 1 for fuel-injection systems of mixture-  
compressing internal combustion engines having externally  
supplied ignition. Fuel injector 1 is particularly suited for  
the direct injection of fuel into a combustion chamber (not  
shown) of an internal combustion engine.

Fuel injector 1 includes a housing body 2 and a nozzle body 3,  
in which a valve needle 4 is positioned. Valve needle 4 is in  
operative connection to a valve closure member 5, which  
cooperates with a valve seat surface 6 to form a sealing seat.  
The fuel injector in the exemplary embodiment is an outwardly  
opening fuel injector 1. It includes an actuator 7, which is  
embodied as a piezoelectric actuator 7 in the exemplary  
embodiment. On one side, the actuator is braced on housing  
body 2, and on the other side it is braced on a shoulder 8,  
which is in operative connection to valve needle 4.  
Downstream from shoulder 8 is a restoring spring 9, which in  
turn is braced on nozzle body 3.

Valve needle 4 has a fuel channel 10 through which the fuel,  
conveyed through an inflow-side central fuel feed 11, is  
guided to the sealing seat. On the inflow side of the sealing  
seat, a swirl chamber 12 is formed into which fuel channel 10  
discharges.

In the neutral state of fuel injector 1, the force of restoring spring 9 acts upon shoulder 8 counter to the lift direction, in such a way that valve closure member 5 is held in sealing contact on valve seat surface 6. When  
5 piezoelectric actuator 7 is energized, it expands in the axial direction, counter to the spring force of restoring spring 9, so that shoulder 8 with valve needle 4, which is joined to shoulder 8 by force-locking, is moved in the lift direction. Valve-closure member 5 lifts off from valve-seat surface 6,  
10 and the fuel supplied via fuel channel 10 is spray-discharged.

When the energizing current is switched off, the axial expansion of piezoelectric actuator 7 is reduced, so that the pressure of restoring spring 9 moves valve needle 4 counter to  
15 the lift direction. Valve closure member 5 sets down on valve seat surface 6, and fuel injector 1 is closed.

Conventional fuel injectors 1 usually have a convex transition region 13 in the area of the sealing seat, as schematically  
20 shown on the right side in Figure 1. This surface shape, which is made up of a surface 14 of nozzle body 3 and a surface 15, abutting thereon on the downstream side, of valve-closure member 5, in most cases is chosen to ensure easy manufacturability and a smooth surface; however, it has the  
25 decisive disadvantage that edges 16, 17 of nozzle body 3 and valve closure body 5, respectively, are lying exposed due to the convex shape of transition region 13, and may be damaged as a result, for instance during transportation or  
installation of fuel injector 1. Since the shape of edges 16,  
30 17 is responsible for the form of the mixture cloud and the jet pattern, damage in this region has an adverse effect on the cylinder charge, on the combustion and on the emission values of the internal combustion engine.

In contrast thereto, according to the present invention, transition region 13 in the area of the region of the sealing seat does not have a convex, but a concave shape, as shown in Figure 1 on the left. The measures according to the present invention are illustrated in Figures 2 and 3 in enlarged form and explained in greater detail in the following description.

Figures 2 and 3 show, in a part-sectional view, the cut-away portion -- denoted by II in Fig. 1 -- from fuel injector 1 configured according to the present invention as shown in Figure 1 in the open and closed state of fuel injector 1. Equivalent components have been provided with matching reference signs.

As already mentioned earlier, conventional fuel injectors 1 have a convex transition region 13 in the area of the sealing seat, where an angle  $\alpha$  enclosed by surfaces 14 and 15 is greater than, or at most precisely  $180^\circ$ . This causes a raised or at best smooth transition region 13 where -- as can be gathered clearly from Figure 3 on the right -- edges 16 and 17 obviously jut out since the sum of two edge angles  $\gamma$  are significantly smaller than  $90^\circ$  due to large angle  $\alpha$ . However, sharp edges 16 and 17 are susceptible to damage such as notches, which may occur when fuel injector 1 is transported or installed.

Therefore, as shown in Figures 2 and 3 on the left, it suggests itself to choose a concave design for transition region 13 of fuel injector 1 in the area of the sealing seat, so that angle  $\alpha$  lying between surfaces 14 and 15 is smaller than  $180^\circ$ . As a result, the sum of both edge angles  $\gamma$  of edges 16, 17 on nozzle body 3 and valve-closure body 5 is greater than  $180^\circ$ , i.e., individual edge angles  $\gamma$  are greater than  $90^\circ$ , and the two edges 16, 17 are obtuse-angled. As a result, edges 16 and 17 are more robust with respect to

damage. In addition, edges 16 and 17 are also protected by the concave form of transition region 13, since they are recessed relative to a surface plane 18, indicated by dashed lines, of fuel injector 1.

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The present invention is not limited to the exemplary embodiment shown, but is also able to be utilized for electromagnetically actuatable fuel injectors 1.